LUBRICATION SYSTEM

FIELD OF THE INVENTION

The present invention relates to fluid lubrication systems. In particular, the present invention relates to a lubrication system including simple and inexpensive means for circulating lubricating or cooling fluid from a reservoir through an interior of a housing and back to the reservoir.

BACKGROUND OF THE INVENTION

Axles and pinions of work vehicles, such as tractors and construction equipment, generate considerable friction and heat during use. As a result, such work vehicles include a lubrication system which circulates a lubricating fluid, such as oil, from a reservoir to the interior of a housing about the axle and which returns excess oil from the interior of the housing to the reservoir. Such lubrication systems typically include a dedicated gear pump which supplies lubricating fluid to the housing extending about the axle. Such lubrication systems typically use one of two methods to remove excess fluid from the housing and to return the excess fluid to the reservoir. One method employs an additional dedicated gear pump which pumps excess oil from the housing and returns the excess fluid to the reservoir. Another method employs an additional dedicated gear pump to pump air into the fluid so as to aerate the fluid prior to the fluid entering the housing about the axle. The aerated fluid adds to the air volume in the axle housing to force excess oil through a drain line back to the fluid reservoir.

Although such lubrication systems have been commonly employed for several years, such lubrication systems have several drawbacks associated with the additional required gear pump necessary to pump excess oil out of the axle housing or to pump air into the fluid to aerate the fluid prior to entering the axle housing. First, the additional gear pump is expensive and space consuming. Second, operation of the additional gear pump requires additional power which increases the operating cost of the work vehicle. Third, operation of the additional gear pump creates excessive undesirable noise.

Thus, there is a continuing need for an axle lubrication system that provides appropriately pressurized fluid for axle lubrication and which removes excess fluid from the axle housing while eliminating the additional gear pump and associated power, noise and operating costs.

SUMMARY OF THE INVENTION

The present invention provides a lubrication system that includes a fluid reservoir, a housing having an interior with an inlet and an outlet fluidly coupled to the reservoir, a fluid pump configured to pump fluid from the reservoir to the interior of the housing through the inlet and a fluid conduit between the fluid pump and the inlet. The conduit has inflow portion having a first cross sectional area, an outflow portion having a second cross sectional area and a throat between the inflow portion and the outflow portion. The throat has an exit and a third cross sectional area less than the first and second cross sectional areas. The conduit further includes an aspiration passage extending from a source of air to a location proximate the exit of the throat. Fluid pumped through the fluid conduit by the pump draws air into the outflow portion through the aspiration passage and aerates the fluid. The aerated fluid expels fluid from the interior of the housing through the outlet and back to the fluid reservoir.

In one exemplary embodiment, the lubrication system further includes a valve between the fluid conduit and the fluid pump, a sensor configured to generate a signal indicative of a viscosity of the fluid and an actuator coupled to the valve. The actuator opens and closes the valve in response to the signal from the sensor.

The present invention also provides a fluid conduit for use in a lubrication system having a fluid reservoir, a housing having an interior with an inlet and an outlet fluidly coupled to the reservoir, a fluid pump configured to pump fluid from the reservoir to the interior of the housing through the inlet. The fluid conduit includes at least one member configured to be fluidly coupled between the pump and the inlet of the housing. The at least one member includes an inflow portion having a first cross sectional area, an outflow portion adjacent the first internal portion and having a second cross sectional area, and a throat between the inflow portion and the outflow portion. The throat has an exit and a third cross sectional area less than the first and second cross sectional areas. The conduit further includes an aspiration passage extending from a source of air to a location proximate the exit of the throat. Fluid pumped through the fluid conduit by the pump draws air into the outflow portion through the aspiration passage to aerate the fluid. The aerated fluid expels fluid from the interior of the housing through the outlet and back to the fluid reservoir.

The present invention also provides a method for lubricating and cooling an axle within a housing. The method includes the steps of pumping fluid from a reservoir through a first passage having a first cross sectional area, through a second passage adjacent the first passage and having a second smaller cross sectional area and through a third passage having a third cross sectional area greater than the second cross sectional area to the interior of the housing. The method also includes the step of providing a source of air to the fluid after the fluid exits the second passage. As a result, air is drawn into the fluid to aerate the fluid. The aerated fluid expels fluid within the housing through an outlet of the housing to the fluid reservoir.

According to one exemplary embodiment, the method additionally includes the steps of generating a signal indicative of a viscosity of the fluid and controlling flow of fluid through the first, second and third passages based upon the signal.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic illustration of a first exemplary embodiment of a lubrication system of the present invention.

FIG. **1A** is a schematic illustration of a second embodiment of the lubrication system of FIG. **1** incorporated into a work vehicle, wherein a valve of the lubrication system is in a closed position.

FIG. **1B** is a schematic illustration of the valve of FIG. **1A** in an open position.

FIG. **2** is a top perspective view of the work vehicle of FIG. **1A** with portions removed to illustrate the lubrication system.

FIG. **3** is a fragmentary top perspective view of a rear axle assembly of the work vehicle of FIG. **2**.

FIG. **4** is a fragmentary front elevational view of the rear axle assembly of FIG. **3** taken along lines **4**—**4**.

FIG. **5** is a sectional view of the axle assembly of FIG. **4** taken along lines **5**—**5**.

FIG. **6** is an enlarged fragmentary sectional view of the rear axle assembly of FIG. **4** taken along the lines of **5**—**5**.

FIG. **7** is a fragmentary sectional view of the rear axle assembly of FIG. **5** illustrating a suction pump of the lubrication system of FIG. **1A**.